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AN EXPERIMENTAL STUDY ON BEHAVIOUR OF CONCRETE REINFORCED WITH BRISTLE COIR FIBERS

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ABSTRACT

The most popular phrase in the civil engineering is 'Concrete is strong in compression but weak in tension'. This is due to the fact that concrete is brittle in nature. This leads to the development of fiber reinforced concrete. Fibers are the small, discontinuous, discrete materials that are uniformly distributed and randomly oriented over the concrete, that are primarily used to increase the structural integrity, tensile strength and reduce the porosity. The recent advancements in the field of fiber reinforced concrete are the use of naturally available materials that includes nylon fibers, polypropylene fibers, coirs etc. Even human hairs are also used as fibers in the concrete. These natural fibers eliminate the demerits of steel fibers such as high cost, getting corroded on exposure etc. Coir fibers have given significant development in the mechanical and durability properties of the concrete. In a broader aspect, there are different types of coir available and are used for different purposes. For instance, coir is used in the manufacture of mattresses, mats etc. A particular type of coir is manufactured from the coconut husks that are particularly used for making bristle brushes called Bristle coir fibers. These fibers are more strong and stiff than normal coirs and other natural materials. Since it is a natural material, on the process of manufacturing it, does not affect the environment and moreover, the replacement of overall concrete content by a small percentage helps to reduce the usage of cement content thereby protects the environment. This paper attempted to include these fibers as a reinforcing material in the concrete such that the enhanced property of the fiber enhances the mechanical of the concrete than other natural fibers and to find an optimum percentage of the fiber.

Key words: Bristle coir fiber, Mechanical properties of concrete.

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1. INTRODUCTION

Concrete is acknowledged to be a relatively brittle material when subjected to normal stresses and impact loads, where tensile strength is approximately just one tenth of its compressive strength. As a result, for these characteristics, concrete flexural members could not support such loads that usually take place during their service life. Historically, concrete member reinforced with continuous reinforcing bars to withstand tensile stresses and compensate for the lack of ductility and strength. Furthermore, steel reinforcement is provided to overcome shear stresses and tensile stress which are highly potential of the concrete member mainly at its critical locations. Even though the addition of steel reinforcement significantly increases the strength of concrete, the development of micro cracks must be controlled to produce concrete with homogenous tensile properties. This involves the introduction of fibers as a solution to develop the flexural and tensile strength of concrete, which is a new form of binder with cement matrices. Fibers are most generally discontinuous, randomly distributed throughout the cement matrices. According to terminology adopted by the American Concrete Institute (ACI) Committee 544, in Fiber Reinforced Concrete, there are four categories namely, SFRC – Steel Fiber Reinforced Concrete, GFRC – Glass Fiber Reinforced Concrete, SNFRC– Synthetic Fiber Reinforced Concrete and NFRC – Natural Fiber Reinforced Concrete.

1.1. Natural Fibers as Reinforcement

Even though the use of steel fibers in concrete has given some tremendous advantages in the property enhancement of the concrete, it affects with some major demerits. Some of them include higher cost, able to get corroded easily in case of exposure to atmosphere thus not suitable in offshore areas and it is not recyclable. In order to eliminate these demerits, there involves the evolution of the usage of the natural fibers. Usage of such natural and some waste materials in construction [1] not only reduces the cost but also helps in waste management and thus making eco-friendly environment.

These fibers are naturally available discrete materials that are available in abundance and are not synthetic or manmade. Several researches has been conducted on the application of the natural fibers in the concrete for increased structural integrity, reduced porosity and increased tensile strength and other mechanical properties of concrete. Some of the fibers include wood, jute, bamboo, sisal and coir and coconut fibers [2]. The latest advancement in the natural fiber reinforced concrete is the usage of human hairs as fibers which has given increased strength in compression and flexure. Literatures reveal that the usage of coir have improved the mechanical properties of the concrete to great extent [3][4]. It is also applied with some composites as well [5][6]. Literatures show that dynamic properties of the concrete have also improved on coir fiber reinforced concrete [7].

1.2. Manufacturing Process of Bristle Coir Fiber

Bristle coir fiber is the long variety of the coir fiber that is extracted from coconut husks. These are the long, strong and stiff fibers than the coir fiber that are particularly used for making bristle brushes. Coir fibers are cheap and are available readily whereas the bristle fibers are to be manufactured and are costlier than coir.

The fibrous husks are soaked in pits or in nets in a slow-moving body of water to swell and soften the fibers. With the help of a process called wet-milling, the long bristle fibers are separated from the shorter mattress fibers beneath the skin of the nut. This turns the raw coconut husks into discrete fibers.

The long fibers are collected separately after the wet milling process and the short mattress fibers are also collected for further processing. The mattress fibers are sifted to remove dirt and other rubbish. After this process, the coir which are bristle is separated for further process and normal coir are collected for various other applications. Then the collected bristle fibers are dried in the sun to remove the moisture. The coir fibre thus extracted is then hackled by steel combs to make the fibre clean and straight and to remove short fibre pieces. Figure 1 shows the step by step manufacturing process of the bristle coir fiber explained above. If required these can be cut into different length. The longer bristle fiber is washed in clean water and then dried before being tied into bundles or hanks. Some mattress fiber is allowed to retain more moisture so it retains its elasticity for twisted fiber production. The coir fiber is elastic enough to twist without breaking and it holds a curl as though permanently waved. Coir bristle fiber can also be bleached and dyed.

Figure 1 Manufacturing Process of Bristle Coir fiber

2. EXPERIMENTAL PROGRAMME

2.1. Materials used

2.1.1. Cement

Ordinary Portland cement of grade 53 has been used in this experiment and it is confirming to IS12269:1987[8]. The specific gravity test for the cement is conducted and it was found to be 3.15.

2.1.2. Coarse Aggregate

Aggregate that is retained on 4.75mm sieve passing through 80mm sieve is known as coarse aggregate. Cube specimens casted for M30 mix using coarse aggregates of maximum sizes 20 mm. The physical properties were tested as per IS2386 (part 1) – 1963[9]. The fineness modulus of coarse aggregate used is 7.22 with a specific gravity of 2.80. Figure 2 shows the sieve analysis curve for coarse aggregate and it is confirming to IS383:1970.

2.1.3. Fine Aggregate

An aggregate that passes through 4.75mm and is retained on 75-micron sieve is known as fine aggregate. Natural river sand with fraction passing through 2.36mm sieve was used and tested as per IS2386 (part 1) – 1963[9]. The fineness modulus of sand used is 3.38 with a specific gravity of 2.65. Figure 2 shows the sieve analysis curve for fine aggregate and it is confirming to IS383:1970 [10].

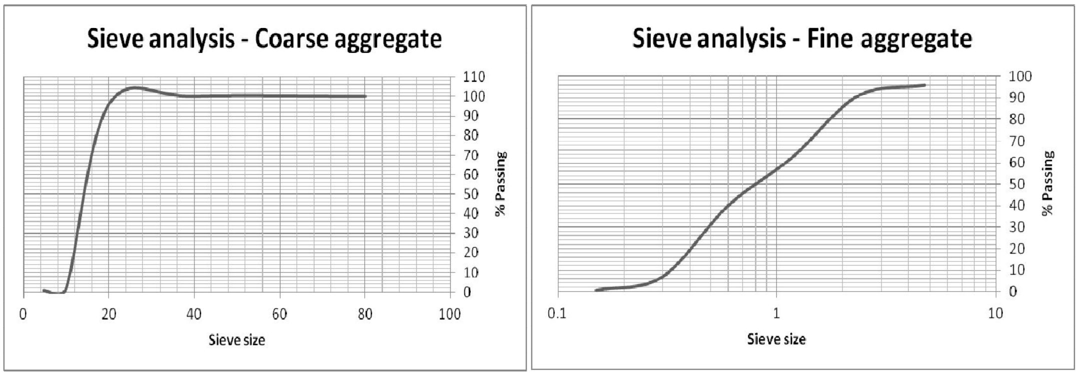

Figure 2 Sieve Analysis Curve

2.1.4. Water

Potable tap water available in the plant conforming to the requirements of IS456 – 2000[11] was used for casting concrete & curing the specimens as well.

2.1.5. Bristle Coir Fiber

The bristle coir fibers of natural colored are purchased from the manufacturing unit Cap Inde coirs, Nagercoil, India. The price of the bristle coir fiber is 5 to 7 times more than that of the normal coir fiber and it is more strong, lengthy and stiff than the coir fibers and it can be noted by appearance as well. Its main application is the preparation of specific bristle brushes. The properties of the bristle coir fiber are shown in table 1.

Table 1 Properties of bristle coir fiber

Properties	Values
Diameter	0.4 mm
Length	10 cm to 25 cm (commercially available)
Bulk density	1.15 g/cc

2.2. Testing Procedure

It is planned to prepare concrete specimens in the form of cubes, cylinders and beams to test for its mechanical properties compressive strength, split tensile strength and flexural strength respectively for the concrete mix design M30[12]. It is planned to add fibers of 1%, 1.5% and 2% by total volume of concrete and it was being cured for 7days, 14 days and 28 days. The

aspect ratio of the fiber adopted was 125 i.e., 50mm length and 0.4mm average diameter of fiber. 36 cubes of size 15cm*15cm*15cm, 36 cylinders of size 15cm diameter and 30cm height and 18 beams of size 0.1m*0.1m*0.5m has been casted and tested after 7,14 and 28 days of curing in water.

3. EXPERIMENTAL TESTS

3.1. Compressive Strength Test

Concrete cubes of size 15cm*15cm*15cm have been casted with three different percentages (1%, 1.5%, 2%) of fibers by total volume of concrete added and has been cured for 7, 14, 28 days in water and the tests has been conducted. Average of 3 specimens has been casted per percentage of fiber per curing day. The test has been conducted with the help of universal testing machine as per codal provision IS516:1959[13]. The experimental setup for the compression test has been shown in figure 3. The ultimate load at which the concrete specimen fails is noted and the compressive strength is calculated using the formula compressive strength = $\frac{P}{A}$.

3.2. Split Tensile Strength Test

Concrete cylinders of size 15cm diameter and 30cm height have been casted with three different percentages (1%, 1.5%, 2%) of fibers by total volume of concrete added and has been cured for 7, 14, 28 days in water and the tests has been conducted. Average of 3 specimens has been casted per percentage of fiber per curing day. The test has been conducted with the help of universal testing machine as per codal provision IS5816:1999[14]. The experimental setup for the split tensile test has been shown in figure 3. The ultimate load at which the concrete specimen fails is noted and the split tensile strength is calculated using the formula split tensile strength = $\frac{2P}{\pi DL}$.

3.3. Flexural Strength Test

Concrete beams of size 10cm*10cm*50cm have been casted with three different percentages (1%, 1.5%, 2%) of fibers by total volume of concrete added and has been cured for 14, 28 days in water and the tests has been conducted. Average of 2 specimens has been casted per percentage of fiber per curing day. The test has been conducted with the help of universal testing machine as per codal provision IS516:1959[13]. The experimental setup for the flexural strength test has been shown in figure 3. Two-point loading method has been adopted and the ultimate load at failure is noted. The flexural strength or modulus of rupture of the concrete beam specimen is then calculated by using the formula flexural strength = $\frac{Pl}{bd^2}$

Figure 3 Experimental Setup for Cube, Cylinder and Beam Specimens

3.4. Young's Modulus

Concrete cylinders of size 15cm diameter and 30cm height have been casted with three different percentages (1%, 1.5%, 2%) of fibers by total volume of concrete added and has been cured for 28 days in water and the tests has been conducted. The test has been conducted with the help of universal testing machine as per codal provision IS516:1959[13]. The deflection has been noted for intervals of load applied and the stress-strain curve has been plotted.

4. RESULTS AND DISCUSSION

4.1. Compressive Strength Test

Table 2 shows the test results for compressive strength of concrete specimens. It is observed that 1% and 1.5% of fiber by volume increase the compressive strength than conventional concrete whereas 2% of fiber by volume decreases the compressive strength. 1% and 1.5% of fiber increases the compressive strength by 4.32% and 9.25% respectively for 28 days of curing. 2% of fiber decreases the strength by 2.5%. Figure 4 gives the comparison chart for 0%, 1%, 1.5%, 2% of fibers by volume and their compressive strength values.

Table 2 Compressive Strength Results

S:NO	Percentage of fiber by volume	Average compressive strength – 7 days of curing (N/mm^2)	Average compressive strength – 14 days of curing (N/mm^2)	Average compressive strength – 28 days of curing (N/mm^2)
1.	0%	24.7	30.5	32.4
2.	1%	25.5	31.8	33.8
3.	1.5%	26	33.1	35.4
4.	2%	23.6	30.4	31.6

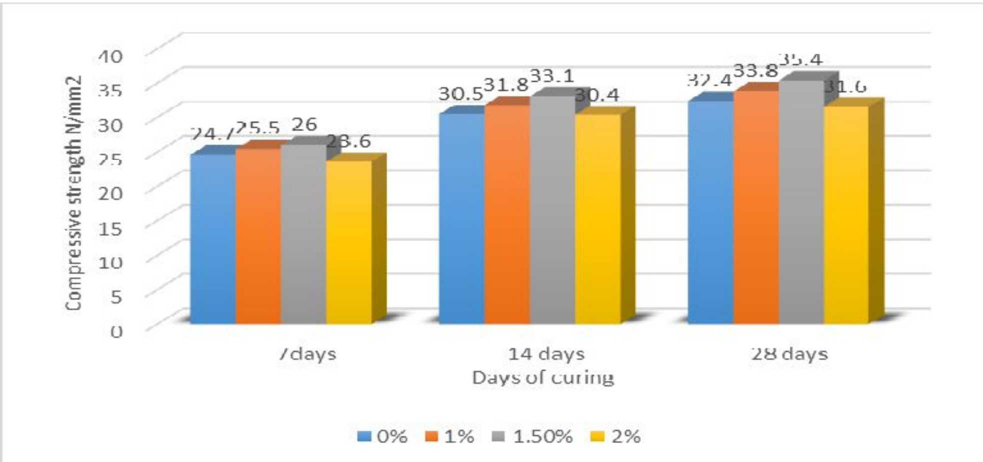

Figure 4 Compressive Strength Comparisons between Percentages of Fiber

4.2. Split Tensile Strength Test

Table 3 shows the test results for split tensile strength of concrete specimens. The main purpose involved in usage of such fibers in concrete is to improve the tensile strength of the concrete. The addition of fibers has given tremendous increase in the split tensile strength. As far as 7 days of curing is concerned 1% of fiber increases the strength by 15.5% and for 1.5% of fiber the strength increases by 21%. 2% of fiber has shown slight increase in the value of

strength. Figure 5 gives the split tensile test chart for 0%, 1%, 1.5%, 2% of fibers by volume and their split tensile strength values.

Table 3 Split Tensile Strength Results

S:NO	Percentage of fiber by volume	Average split tensile strength – 7 days of curing (N/mm^2)	Average split tensile strength – 14 days of curing (N/mm^2)	Average split tensile strength – 28 days of curing (N/mm^2)
1.	0%	2.551	2.641	2.806
2.	1%	2.951	3.088	3.103
3.	1.5%	3.106	3.205	3.264
4.	2%	2.653	2.780	2.814

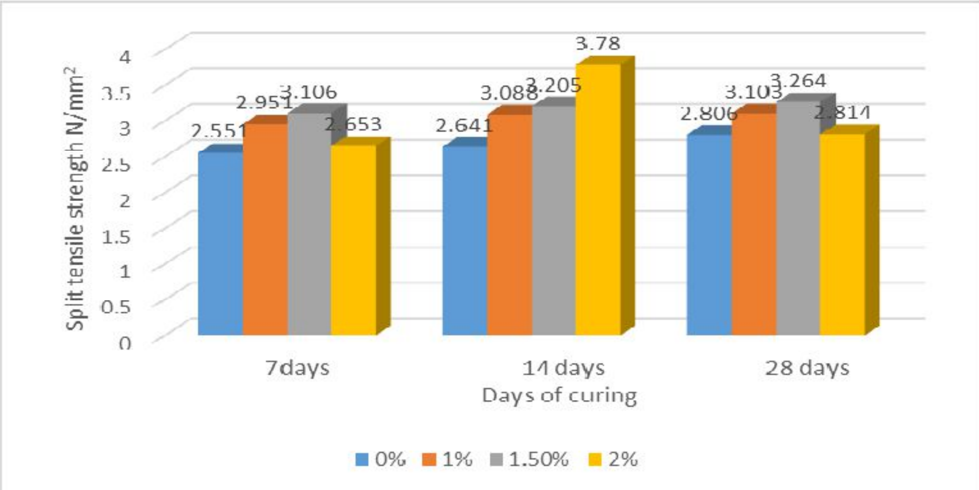

Figure 5 Split Tensile Strength Comparison between Percentages of Fiber

4.3. Flexural Strength Test

Table 4 shows the test results for flexural strength of concrete specimens. As in the compressive strength, 1% and 1.5% of fibers has shown some improvement in the flexural strength. 7% increase in 1% fiber whereas 1.5% fiber at 28 days of curing is significant as it shows 35% increase in strength. 2% of fiber slightly decreases the strength by 4%. Figure 6 gives the comparison chart for 0%, 1%, 1.5%, 2% of fibers by volume and their flexural strength values.

Table 4 Flexural strength results

S:NO	Percentage of fiber by volume	Average flexural strength – 14 days of curing (N/mm^2)	Average flexural strength – 28 days of curing (N/mm^2)
1.	0%	3.70	4.20
2.	1%	3.75	4.50
3.	1.5%	4.50	5.75
4.	2%	3.50	4.00

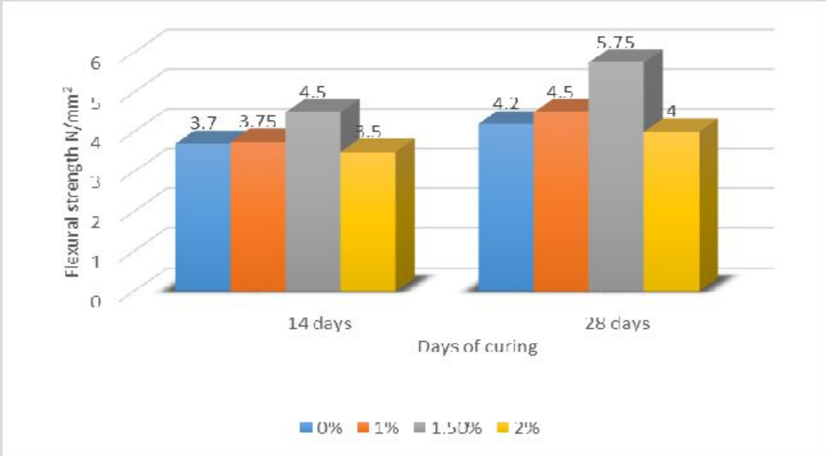

Figure 6 Flexural Strength Comparisons Between Percentages of Fiber

4.4. Stress Strain Curve

From the load and deflection values obtained from the experiment, the values of stress and strain are obtained and the stress strain curve has been plotted. Figure 7 shows the stress strain curve comparison between conventional concrete and bristle coir fiber reinforced concrete (BCFRC).

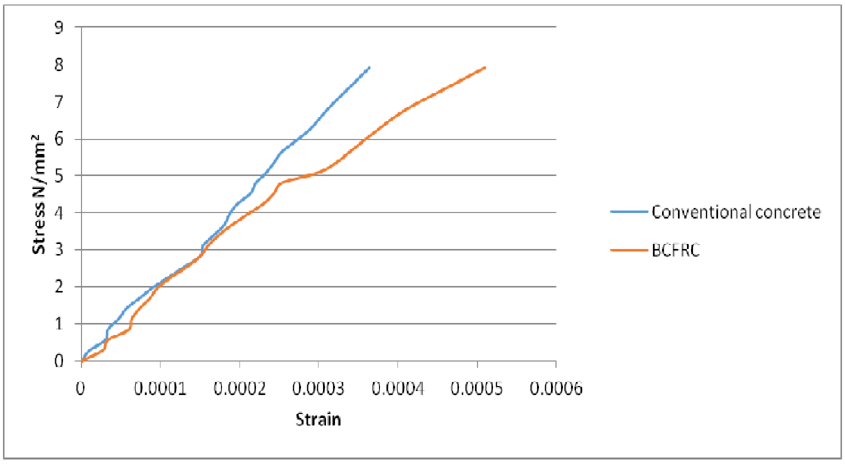

Figure 7 Comparison of Stress Strain Curve between CC and BCFRC

5. CONCLUSION

In this paper, Bristle coir fibers are used as reinforcement in the concrete because of the enhanced property of this fiber compared to normal coir fibers. The mechanical properties of the fiber reinforced concrete with different percentages of fibers by total volume of concrete have been investigated and the test results are discussed.

- It is clear from the results that, for M30 grade of concrete with the aspect ratio of 125, 1% and 1.5% of the fibers by total volume of concrete has given tremendous increase in the strength of the concrete compared to conventional concrete (CC).
- The optimum percentage addition of fibers for the overall improvement in the strength of the concrete is 1.5%. It increases the compressive strength of concrete after 28 days of curing by 9.25% than CC.
- It shows tremendous increase in the split tensile strength and flexural strength as well. The split tensile strength of the concrete after 28 days of curing is increased up to 16% and

modulus of rupture of the concrete is increased up to 35% than CC for 1.5% of fiber addition by total volume of concrete.

- Though 1% of fiber also improves the overall strength of concrete, 1.5% gives the better results and it is considered to be optimal percentage of fiber addition.
- 2% of fiber by total volume of concrete shows improvement slightly in the split tensile strength whereas it shows decrease in the compressive strength of concrete.

REFERENCES

[1] M Sivaraja, S Kandasamy and A Thirumuraghan. S 2010. Mechanical strength of fibrous concrete with waste rural material. Journal of Scientific and Industrial Research Vol.69, April 2010, pp.308-312.

[2] Shreeshail.B.H, Jaydeep Chougale, Dhanraj Pimple, Amar Kulkarni, Effects of coconut fibers on the properties of concrete, International journal of research in engineering and technology, Volume 03 Issue 12, Dec-2014, 5 – 11.

[3] S. Sastha Arumuga Pandi, S. Yamini Roja, G. Jenitha and K. Alagusankareswari, Experimental Study on Behavior of Coir Fibre Reinforced Concrete. *International Journal of Civil Engineering and Technology,* 8(2), 2017, pp. 141–147.

[4] D.M. Parbhane, S.B. Shinde, Strength Properties of Coir Fiber Concrete, *International Journal of Civil Engineering and Technology*, 5(2), 2014, pp. 20–24.

[5] J. Sahaya Ruben, Dr. G. Baskar, Experimental Study of Coir Fiber as Concrete Reinforcement Material incement Based Composites, Int. Journal of Engineering Research and Applications, ISSN : 2248-9622, Vol. 4, Issue 1 (Version 3), January 2014, pp.128-131

[6] V.G. Geethamma, G. Kalaprasad, Gabriel Groeninckx, Sabu Thomas,(2005), Dynamic mechanical behavior of short coir fiber reinforced natural rubber composites polymer Applied science and manufacturing, 36, 1499-1506.

[7] Majid Ali , Anthony Liu, Hou Sou, Nawawi Chouw, Mechanical and dynamic properties of coconut fibre reinforced concrete, Construction and Building Materials 30 (2012) 814–825.

[8] IS-12269., Indian Standard specification for 53 grade ordinary Portland cement - guidelines (Bureau of Indian Standards), 1987, New Delhi, India.

[9] IS-1286 part 1., Indian Standard method of test for aggregate for concrete (Bureau of Indian Standards), 1963, New Delhi, India.

[10] IS-383., Indian standard specification for coarse and fine aggregates from natural source of concrete - guidelines (Bureau of Indian Standards), 1970, New Delhi, India.

[11] IS-456., Indian Standard Plain and Reinforced Concrete -Code of Practice (Bureau of Indian Standards), 2000, New Delhi, India.

[12] IS-10262., Indian Standard concrete mix proportioning – guidelines (Bureau of Indian Standards), 2009, New Delhi, India.

[13] IS-516., Indian Standard methods of test for strength of concrete (Bureau of Indian Standards), 1959, New Delhi, India.

[14] IS-5816., Indian Standard splitting tensile strength of concrete - methods of test (Bureau of Indian Standards), 1999, New Delhi, India.